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VOL. 87 FRIDAY, MARCH 11, 1938 No. 2254

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

THE APPLICATION OF ISOTOPES TO THE STUDY OF INTERMEDIARY METABOLISM[1]

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THE number of organic compounds involved simultaneously in the multitude of diverse chemical reactions in the living organism is exceedingly large. Substances are continually being degraded, while their split products are linked together again to form new compounds, and all these reactions and their reaction products are held in equilibrium so that the composition of the cell and the organism stays constantly within narrow limits.

By adding to this complicated system an excess of one of the components, it is in many cases possible to follow its conversions, provided one has some general idea as to its fate. Herein lies the principle of the classical balance experiments. In order to determine the fate of one of the constituents of the organism, the substance is given in large quantities and the tissues or excreta are investigated for the presence of related compounds in abnormal amounts. This method has proved to be extremely valuable, and most of our knowledge of intermediary metabolism is based on experimentation of this kind. Unfortunately this method has theoretical limitations. Many body constituents, especially the more active ones, are never produced in excess of the animal's requirements, even if the building material is available in large quantities. Another obstacle which sometimes makes the interpretation of such balance studies extremely difficult is the known fact that one substance may induce the formation of others without itself being involved in the synthesis. Thus, for instance, insulin induces glycogen formation, and fat induces an increased for-

[1] This article contains the material presented in two papers at the meeting of the American Chemical Society at Rochester, N. Y., September, 1937.

mation of cholesterol, without taking direct part in the transformations. This weakness of biological balance studies has aptly been illustrated by comparison with the working of a slot machine. A penny brings forth one package of chewing gum; two pennies bring forth two. Interpreted according to the reasoning of balance physiology, the first observation is an indication of the conversion of copper into gum; the second constitutes proof.

Several attempts have already been made to overcome the difficulties by labelling the compounds to be given with an easily detectable chemical group. A method based on this principle may give direct evidence, more convincing than the circumstantial evidence of the balance experiments. For example, hydrogen of fatty acids has been replaced by halogens and the determination of organic bound halogen used for the study of the transportation of fatty acids in the animal organism. Halogenated fatty acids, however, are so different in their physical and chemical behavior from the non-halogenated ones that the highly sensitive cell does not treat them alike. In order successfully to label an organic compound for metabolism studies, the resulting compound has to be of such a nature that it is treated by the tissues in exactly the same way as the normal analogue. On the other hand, the chemist must be able not only to detect the label, but to determine it in small quantities and in high dilutions. For obvious reasons the only type of label which will fulfil these requirements is to be found in the isotopes of the elements which constitute organic matter. Organic compounds, for instance, which have hydrogen or nitrogen atoms replaced by the corresponding isotopes have practically the same properties as the normal substances.

The separation of the isotopes of the same element is extremely difficult, and only in a few instances have such attempts been successful. Of the various elements, the concentration of the isotopes of hydrogen is the most easily accomplished in the laboratory, but the living cell is unable to perform this operation to appreciable extent. Wherever hydrogen occurs in nature, the concentration of deuterium in the total hydrogen is practically uniform (0.02 per cent.), independent of the source (sea water, lake water, biological fluids, etc.). The same concentration of deuterium as is found in water is also found in the hydrogen of organic material,[2] which is ultimately synthesized by living cells from carbon dioxide and water. The even distribution of deuterium in water and organic matter may be taken as proof that the cell does not discriminate against either form of hydrogen.

The first to realize the importance of isotopes for biological work was von Hevesy, who applied them to the investigation of the metabolism of inorganic material as early as 1926.[3] He investigated the fate of lead in the organism by adding to it a minute amount of one of its radio-active isotopes, Ra D, which can not be separated from lead by physical or chemical means. The radio-activity of the ash of organs indicates the distribution of lead in the animal after its administration. Recently he has investigated the transportation of phosphoric acid in higher plants,[4] yeast[5] and animals[6] by giving these organisms phosphoric acid containing radio-active phosphorus. His finding that ingested phosphate is distributed in animals not only throughout all the organs but also in the bones and teeth, indicates that even these structural elements are continuously and actively involved in salt metabolism. By using the same material[7] the uptake of phosphoric acid into phospholipids was studied.

The application of isotopes to the study of intermediate metabolism involves methods which are different in principle from those methods used for the study of salt metabolism. No radio-active isotopes of the elements C, H, N or O are known with a half-life long enough to permit their use for organic syntheses and metabolism experiments. One is limited to the use of stable isotopes which have been concentrated from natural mixtures. By devising methods for such fractionation, H. C. Urey has made possible a new approach to biological problems.

The study of the metabolism of organic compounds with the aid of stable isotopes involves the preparation of organic compounds in which one or more atoms are replaced by their respective isotopes. The only isotopes which have been used so far are those of hydrogen and nitrogen. As by far the most experience has been had with deuterium, we should like to discuss its application first.

In "labelling" an organic compound with deuterium, the isotope must be introduced in such a way that it will not be lost from the molecule during the course of metabolic reactions.[8] In other words, the deuter-

[2] F. Breusch and E. Hofer, *Klin. Woch.*, 13: 1815, 1934; M. Dole, *Jour. Am. Chem. Soc.*, 58: 580, 1936; M. Dole and R. B. Gibney, *Jour. Am. Chem. Soc.*, 58: 2552, 1936.

[3] G. Hevesy, *Biochem. Zeits.*, 173: 175, 1926.

[4] G. Hevesy, K. Linderstrom-Lang and C. Olsen, *Nature*, 139: 149, 1937.

[5] G. Hevesy, K. Linderstrom-Lang and N. Nielsen, *Nature*, 140: 725, 1937.

[6] O. Chievitz and G. Hevesy, *Nature*, 136: 754, 1935.

[7] G. Hevesy and E. Lundsgaard, *Nature*, 140: 275, 1937; L. Hahn and G. Hevesy, *Skand. Arch. Physiol.*, 77: 148, 1937; C. Artom, G. Sarzana, C. Perrier, M. Santangelo and E. Segre, *Nature*, 139: 836, 1937.

[8] R. Schoenheimer and D. Rittenberg, *Jour. Biol. Chem.*, 111: 163, 1935.

ium atoms should be stably bound to the carbon skeleton. From our knowledge of the reactions of organic compounds, it is in general possible to predict which of the hydrogen atoms will exchange with the hydrogen of the water in which they are dissolved. The use of deuterium has confirmed the prediction that the hydrogen atoms in carboxyl, hydroxyl, amino and other polar groups are labile and exchangeable with the hydrogen atoms of water. Since biological reactions proceed in an aqueous phase, all substances which contain deuterium in such labile positions must lose it by exchange as soon as they are dissolved in the body fluids. However, hydrogen bound directly to carbon, as in methyl or methylene groups, is, in general, stable and can not be removed by exchange with water, even under such drastic conditions as treatment with hot acid or alkali.[9] So far there has been no indication that such carbon bound hydrogen as is found to be stable *in vitro* is labile in the animal. There is good reason to believe that, if such stable deuterium is removed *in vivo* from the carbon to which it is attached, the removal is due to a biochemical reaction rather than to a simple physical exchange. This point will be discussed later.

There are many methods for the preparation of compounds containing carbon bound deuterium, the most convenient of which is the hydrogenation of double bonds with deuterium.[10] Crotonic acid when treated in this way will yield butyric acid, and oleic acid will yield stearic acid, both reaction products containing stably bound deuterium at predetermined positions in the molecule. Two other methods are based on the fact that stable hydrogen atoms of ordinary compounds may under certain exceptional conditions become labile and exchangeable with deuterium atoms of other substances. Thus many compounds, when treated with concentrated deutero-sulfuric acid (D_2SO_4) at high temperature, exchange otherwise non-exchangeable hydrogen with the deuterium of the sulfuric acid.[11] Moreover, some compounds exchange carbon bound hydrogen with the deuterium of heavy water when treated at high temperature with a suitable catalyst,[12] and fatty acids prepared by this method[13] seem to be highly valuable for metabolism studies. Another process, which will be mentioned later, is that of biological synthesis.

A prerequisite of the deuterium technique is the quantitative determination of deuterium in organic compounds. The analysis[10] is based on the fact that organic matter, when burned, yields its hydrogen in the form of water, and if deuterium is present in it this will form an equivalent of heavy water. The analysis of deuterium in organic compounds is thus in principle the determination of heavy water in the water of combustion. The methods of heavy water analysis which have been developed in different laboratories in recent years are so sensitive that a concentration as low as 0.02 per cent. can be accurately and routinely determined. Because of this the biological application of the deuterium technique is extremely sensitive. If an animal were fed a biological compound such as stearic acid in which 5 per cent. of all its hydrogen atoms are replaced by deuterium, the compound[14] could be diluted with more than 1,000 times its weight of ordinary stearic acid or an equivalent amount of other material before the analytical methods would lose track of it. Thus in general, only a small amount of a deutero-compound need be given to the animals, and even if only a fraction is converted into another substance, the analytical methods will still reveal the conversion. While this general procedure has already been applied to a number of different physiological compounds, we shall discuss, in this paper, only its application to fat metabolism.

The deuterium procedure may be employed for the study of the transport of ingested material, even if given in small quantities. On feeding deutero-fats,[15] it was found that a small part is deposited in the internal organs, such as the liver, while a very large part is deposited in the fat depots prior to its utilization. This holds true even when the amount of fat in the diet is small. Between 20 and 40 per cent. of the labelled fat was invariably recovered from the depots. Cavanagh and Raper,[16] employing the same methods, observed the transport of fatty acids through the phospholipid stage. This is in agreement with the findings of Sinclair on the rôle of phospholipins in fat metabolism.

The deposition of food fatty acids in the fat depots is well in accord with the known fact that the properties of depot fats depend on the quality of the diet.

[9] There are a number of general exceptions, such as when the hydrogen is adjacent to a carbonyl or phenol group, etc., or with some compounds of small molecular weight.

[10] D. Rittenberg and R. Schoenheimer, *Jour. Biol. Chem.*, 111: 169, 1935.

[11] C. K. Ingold, C. G. Raisin and C. L. Wilson, *Jour. Chem. Soc.*, 1643, 1936; R. Schoenheimer, D. Rittenberg and A. S. Keston, *Jour. Am. Chem. Soc.*, 59: 1765, 1937.

[12] C. Horrex and M. Polanyi, Memoirs and Proceedings of Manchester Literary and Philosophical Society, 80: 33, 1935–1936.

[13] Unpublished data of W. E. van Heyningen with the authors.

[14] On combustion, the compound will yield water containing 5 per cent. heavy water. Unless otherwise stated, the deuterium content in substances mentioned in this paper means deuterium which is stably bound in the molecule.

[15] R. Schoenheimer and D. Rittenberg, *Jour. Biol. Chem.*, 111: 175, 1935.

[16] B. Cavanagh and H. S. Raper, *Nature*, 137: 233, 1936.

These changes occur, however, to only a limited extent. All animals have a tendency to reproduce from different diets a depot fat, the composition of which is characteristic for the species. The deposition of the fats in the depots is thus followed by a change in properties. The deuterium method has enabled the physiologist to correlate this assimilation of food fat with the conversion of one kind of fatty acid to another.

The principle underlying the general experimental procedure is the following: If a deutero-compound A is given to an animal, and if subsequently a compound B, also containing deuterium, is isolated from the body, the deuterium content of B may be taken as proof that B was derived from A.

The majority of investigators have postulated the biological desaturation of fatty acids, such as the formation of oleic acid from stearic acid. This hypothesis, however, was far from being generally accepted because definite proof of the reaction was still lacking. Proof was supplied by the deuterium technique, when oleic acid with a high deuterium content was isolated from mice which had been fed with deutero-stearic acid.[17] These desaturation experiments gave no indication as to the locality of the reaction in the organism. Some investigators have suggested that the desaturation takes place in the intestinal wall during absorption of the fatty acid. Work by Dr. Smith Freeman, of Northwestern University, in collaboration with the authors[18] now shows this view to be untenable. Deutero-saturated fatty acids were fed to dogs and the absorbed material isolated from a lymph fistula directly after it had passed the intestinal wall. The deuterium analysis of the unsaturated fatty acids gave no indication of desaturation during absorption. The process must occur in other organs, most probably in the liver.

The question whether the organism is also capable of the reverse process, namely, the saturation of unsaturated fatty acids, was decided in the affirmative.[19] After feeding deutero-oleic acid to mice, deuterium was found in the saturated acids, which could therefore have had no other origin than from the administered material.[20]

Another type of biological conversion of fatty acids which would have been difficult to follow by other methods was that of the degradation of stearic acid into palmitic acid,[21] a process which involves the shortening of the fatty acid chain by two carbon atoms. These experiments, considered as a whole, clearly indicate that the three main constituents of animal fats are interconvertible and show one of the means by which animals reproduce their typical depot fat.

The typical acids of plant and animal fat contain 16 and 18 carbon atoms. As has been mentioned before, a large part of these acids is always recoverable from the fat depots after they have been fed. Eckstein[22] and others have evidence that fatty acids with short chains of 4 and 6 carbon atoms (butyric and caproic acid) are not found in the depots, even when they are fed in considerable quantities. This finding was corroborated by experiments in which the corresponding deutero-acids were fed.[23] Not only were these fatty acids not stored, but the deuterium administered in the acids was found as heavy water in the body fluids shortly (6 hours) after feeding. These results, and those of other experiments on these two acids, clearly indicate that, in contrast to the higher ones, they were rapidly and completely burned and not used for fat formation. The rapid degradation of butyric and caproic acids thus seems to resemble the labile metabolism of the carbohydrates rather than that of the higher fatty acids.[24]

While the field of application of the deuterium technique to conversion processes is very wide, the method has strict limitations. The physiologist, when studying conversions of organic compounds, is interested in the fate of the carbon rather than that of the hydrogen. The metabolic conversion of sugar into fats connotes the utilization of the carbon for the fat formation; the fate of the hydrogen is of secondary interest. The direct application of the deuterium technique is obviously excluded, when the hydrogen or deuterium becomes detached from the carbon during conversion. It is highly improbable that deuterium can be used directly for the solution of the much-labored question of the metabolic sugar formation from fatty acids. While it has been established beyond doubt that fatty acids with an odd number of carbon atoms form sugar, there is no proof that this is true for the natural fatty acids with an even number of carbon atoms.

[17] R. Schoenheimer and D. Rittenberg, *Jour. Biol. Chem.*, 113: 505, 1936.

[18] Unpublished data.

[19] D. Rittenberg and R. Schoenheimer, *Jour. Biol. Chem.*, 117: 485, 1937.

[20] At the time of the experiment no method existed for the laboratory preparation of deutero-oleic acid. This substance was, therefore, prepared biologically by feeding mice deutero-stearic acid and isolating deutero-oleic acid from the carcasses.

[21] R. Schoenheimer and D. Rittenberg, *Jour. Biol. Chem.*, 120: 155, 1937.

[22] H. C. Eckstein, *Jour. Biol. Chem.*, 81: 613, 1929; 84: 353, 1929.

[23] D. Rittenberg, R. Schoenheimer and E. A. Evans, Jr., *Jour. Biol. Chem.*, 120: 503, 1937.

[24] The interpretation given in the popular press that butter fat burns faster than other fats is incorrect. The acids investigated constitute only a small fraction of the fatty acids of butter, and corresponding experiments have not yet been carried out on the metabolism of the other fatty acids of butter. The suggestion that butter fat is not fattening lacks all foundation.

An exploratory experiment has been carried out on the applicability of the deuterium technique to the study of sugar formation.[23] Propionic acid, which contains 3 carbon atoms, is known to be a "sugar former," and when this compound is given to a diabetic animal, an equivalent amount of carbon can be recovered from the urine in the form of extra sugar. When deutero-propionic acid was given to diabetic dogs or rats, the extra sugar formation was observed just as after feeding ordinary propionic acid, yet the sugar isolated from the urine contained only an insignificant amount of deuterium. The isotope must have been lost during the conversion—most probably when intermediate compounds were formed in which the hydrogen (or deuterium) was exchangeable with the hydrogen of the body fluids.

In a number of cases where the conversion of one substance into another can not be followed on account of the labilization of the deuterium in the intermediate steps, a reverse method may be employed.[23] Instead of introducing the deuterium into the organic molecule, it is introduced as heavy water into the body fluids, or in other words, into the medium in which the conversions are to take place. If chemical reactions are carried out *in vitro* in a medium of heavy water instead of ordinary water, deuterium may enter into the reactions and subsequently be found in stable positions in the end-products. This is particularly true if reductions or condensations are involved. If the same reactions are carried out in animals whose body fluids contain heavy water, the deuterium may also be found in the products of biological synthesis. The formation of fats from carbohydrates can probably not be followed by the first method, that is, with sugars labelled with deuterium, as the isotope will be lost from the molecule during the production of intermediary compounds.[25] But, when the fat formation from sugars is studied with animals, the body fluids of which contained heavy water, the resulting fatty acids were characterized by their stably bound deuterium,[26,27] the presence of which was taken as an indication of the new formation of these fatty acids.

This conclusion, however, presupposed that the fatty acids themselves had not taken up their deuterium by simple exchange with the heavy water of the body fluids in which they were dissolved or suspended. In all biological experiments in which chemical reactions are investigated by the uptake of deuterium from the body fluids extreme care must be taken in the interpretation of the findings. Proof is essential that fatty acids, which are not undergoing chemical reactions, do not exchange hydrogen with that of the water in which they are dissolved. This proof of the stability of the hydrogen in the compounds when demonstrated in the test-tube is not sufficient indication of its stability in the living organism. Enzymes may exist which labilize otherwise stable hydrogen atoms without further changing the total molecule. In the case of most compounds the proof of the "biological hydrogen stability" can be furnished only with the greatest difficulty, but it has already been possible to supply it for a few substances. The biological stability of the hydrogen in a compound can be accepted, if this substance can be isolated in the deuterium-free state from a living organism, the body fluids of which have contained heavy water for a considerable period. Demonstration of such "biological hydrogen stability" has as yet been supplied only for the fatty acids, cholesterol and the essential amino acid lysine. Deuterium-free fatty acids[26] and cholesterol[27] were isolated from chicks which had developed in eggs, the fluids of which had been enriched with heavy water. Deuterium-free lysine was isolated from mice whose body fluids had contained heavy water for a period of more than 3 months.[28] If the hydrogen of these compounds were exchangeable under biological conditions with the hydrogen of the body fluids, the compounds isolated from these metabolically active organisms should have contained deuterium. If, under other conditions, deuterium is introduced biologically into these substances, such a finding must be taken as an indication for a chemical reaction which had occurred in the animal. The introduction of deuterium into fatty acids in mice from the body fluids demonstrates the occurrence of chemical reactions, namely, fat formation, rather than mere physical exchange.

As has just been mentioned, fatty acids do not take up deuterium during the active development of the chick embryo, but they do so in growing and adult mice, when the animal takes up food. The formation of fatty acids from carbohydrates in mice proceeds even on constant body weight. A breakdown of fatty acids concurrent with a new formation must have taken place. This turnover of fatty acids was found to be unexpectedly rapid, and is probably dependent not only on the quality of the diet but also on a great number of other physiological influences.

Cholesterol, also, takes up deuterium from the body fluids of adult animals;[27] the rate is slower than that for the fatty acids, indicating a slower synthesis of cholesterol. However, the total amount of deuterium introduced into the cholesterol during its formation is so large that it can be explained only by a synthesis

[25] R. Sonderhoff and H. Thomas (*Annalen*, 530: 195, 1937) have published an interesting paper in which they report on the conversion by yeast of tri-deutero-acetic acid into fatty acids and unsaponifiable matter.

[26] R. Schoenheimer and D. Rittenberg, *Jour. Biol. Chem.*, 114: 381, 1936.

[27] D. Rittenberg and R. Schoenheimer, *Jour. Biol. Chem.*, 121: 235, 1937.

[28] Unpublished data of G. L. Foster with the authors.

from a large number of small molecular units, such perhaps as the intermediates of fat or carbohydrate metabolism.

A highly interesting experiment in which similar methods and principles were employed is that of Ussing[29] on glycogen formation. After the body fluids of rats had been enriched with heavy water, large amounts of monohexoses were fed. The glycogen isolated from the liver contained such large concentrations of stably bound deuterium that it was suggested that glycogen formation does not proceed by simple coupling of hexose molecules, but only after their preliminary degradation to smaller molecules.

The use of deuterium as a tool for the study of intermediary metabolism is still new. While it has as yet been applied only in a limited number of investigations (experiments on sterols and bile acids),[30,31] we have no doubt that the scope of its application is much wider and that if the proper procedures are developed, it can be used for the study of almost all physiological compounds. Synthetic methods for the preparation of other deutero-compounds must be devised, and the physical and chemical properties of these new types of organic compounds must be studied more thoroughly. By far the most important task is the further investigation of the stability of carbon-bound hydrogen atoms *in vivo*.

Little has been done on the use of other isotopes for the investigation of intermediary metabolism. The oxygen isotope (O^{18}) will probably prove to be of great utility in the study of many chemical reaction mechanisms, but its application as a label for metabolic processes seems to be limited. Most cell constituents contain oxygen, but the groupings which contain this element (COOH, OH, C=O, etc.) are metabolically so active that even unimportant changes (esterification, etc.) may lead to a loss of this isotope.

The nitrogen isotope (N^{15}), on the other hand, will probably prove to be of great utility in the important field of nitrogen metabolism. The natural abundance of heavy nitrogen in all samples investigated, whether inorganic or organic, is the same, namely 0.37 atom per cent. Urey and his collaborators have succeeded in concentrating this isotope.[32] The analytical methods for its determination involve the use of the mass spectrometer. This method is sensitive enough to determine an increase of 0.003 per cent. of N^{15}. In other words, an amino acid, such as glycine, synthesized with an isotopic mixture containing 2.5 atom per cent. of N^{15} can be diluted over a hundred times with ordinary glycine and still be determined by the mass spectrometer.

The experience gained with deuterium in metabolism studies has demonstrated the importance of the stability of the isotopic tracer in the molecule. Just as stably bound hydrogen must be used for metabolic experiments, so can only such nitrogen as is stably bound and does not exchange with the nitrogen of other substances be employed for following the fate of nitrogenous compounds. A number of amino acids (glycine, alanine, phenylalanine, tyrosine, glutamic acid and norleucine) containing an increased amount of N^{15} have already been synthesized.[33] The stability of the nitrogen in amino acids has been investigated by treating a system of one isotopic and one normal compound (amino acid or ammonia) in aqueous solution at 100° C. In no case was the isotope observed to shift from one compound to another.[34] It is probable that the stability, observed *in vitro*, also exists *in vivo*; only chemical reactions (*e.g.*, deamination) will lead to a loss of the label.

So far only one series of biological experiments has been carried out with the nitrogen isotope. To test its suitability as a label for amino acids, isotopic glycine was subjected to a simple biochemical reaction, the coupling with benzoic acid to form hippuric acid. This reaction has already been extensively studied in many laboratories, and it is well known that animals when fed benzoic acid can supply more glycine for its detoxication than was originally present in the body. Animals thus have the ability to form comparatively large quantities of glycine from other nitrogenous compounds, and it was uncertain whether they can utilize preformed glycine for this reaction, or whether the benzoic acid is primarily coupled with another nitrogenous substance, which subsequently is degraded to hippuric acid. Isotopic glycine was given to rats together with benzoic acid, either *per os* or subcutaneously,[34] and the isotope content of the urinary hippuric acid showed that the administered glycine was used for the hippuric acid synthesis.

It would be premature, on the basis of these experiments, to predict the types of metabolism problems for which the nitrogen isotope can be employed. The direction in which this field will develop depends upon whether the animal can use ammonia for the preparation of amino acids, or whether this synthesis is limited to the use of carbon-bound nitrogen. While the occurrence of amino acid synthesis in animals is well established, the source of the nitrogen employed in such reactions is still obscure. These new techniques in biochemical practice may soon answer this and other fundamental questions of metabolism.

[29] H. H. Ussing, *Skand. Arch. Physiol.*, 77: 85, 1937.

[30] R. Schoenheimer, D. Rittenberg and M. Graff, *Jour. Biol. Chem.*, 111: 183, 1935.

[31] R. Schoenheimer, D. Rittenberg, B. N. Berg and L. Rousselot, *Jour. Biol. Chem.*, 115: 635, 1936.

[32] H. C. Urey, M. Fox, J. R. Huffman and H. G. Thode, *Jour. Am. Chem. Soc.*, 59: 1407, 1937; *Jour. Chemical Physics*, 5: 856, 1937.

[33] Unpublished data of S. Ratner with the authors.

[34] R. Schoenheimer, D. Rittenberg, M. Fox, A. S. Keston and S. Ratner, *Jour. Am. Chem. Soc.*, 59: 1768, 1937.

OBITUARY

ARTHUR WARE SLOCOM

1860–1937

SCIENCE is served in many ways. She is doubtless fond of her spectacular minions whose names commonly appear on important tomes, but certainly she must also cherish her unsung servants who are merely listed in the same works as those "to whom acknowledgments are due." High in the ranks of the latter stood Arthur Ware Slocom, assistant curator of invertebrate paleontology at Walker Museum, University of Chicago, who died on November 20, 1937, in his seventy-eighth year.

Mr. Slocom was born in Milford, Mass., on November 8, 1860, the son of Lewis Slocom and Lucinda Ware. He derived a modest satisfaction from the fact that his ancestry was interwoven with the warp and woof of Colonial New England's best. He was a descendant of Dr. Samuel Fuller of the Mayflower, and six of his forebears were Minute Men who responded to the Lexington Alarm of April 19, 1775. It is not surprising, therefore, that he was an ardent and accomplished genealogist, and for a score of years was an officer of the Illinois Society, Sons of the American Revolution.

After a common school education Mr. Slocom went to Milwaukee to enter the straw hat business with an uncle. An increasing interest in science led him to enroll in 1896 for special work in paleontology under Dr. Stuart Weller at the University of Chicago. Although Dr. Weller was ten years his junior, there thus began their happy thirty-year relationship of mentor and student, terminated only by Dr. Weller's untimely death in 1927. At Dr. Weller's suggestion Mr. Slocom spent the year 1898–99 at Ward's Natural Science Establishment at Rochester, N. Y. The next year he was a member of the staff of the Milwaukee Public Museum. Then began in 1901 a profitable thirteen-year term as invertebrate paleontologist for the Field Museum of Natural History, Chicago. In 1914 he again became directly associated with Dr. Weller as assistant curator at the Walker Museum, a position which he held with quiet competence for twenty-three years.

Mr. Slocom published a number of papers between 1906 and 1924. Of these eight, dealing almost entirely with fossil echinoderms and trilobites, represent significant researches. His major contributions to science, however, are not to be found in his publications. He arranged and catalogued the largest collection of Paleozoic invertebrates in any educational institution, prepared hundreds of fossils for study, made up the plates for innumerable papers, and, more or less surreptitiously, guided literally dozens of candidates for the doctorate through their thesis problems. Little wonder that scores of genera and species of Paleozoic fossils have been named in his honor.

Mr. Slocom, whose perpetual good humor and self-sacrificing character were proverbial, was intellectually keen until the day of his death, having been working on Devonian trilobites the last few weeks of his final illness. He is survived by his wife, an adopted daughter and by many generations of graduate students whom he regarded as "his boys," and who, to a man, rightly feel that "Walker Museum can never be the same again."

CAREY CRONEIS

WALKER MUSEUM,
UNIVERSITY OF CHICAGO

RECENT DEATHS AND MEMORIALS

DR. JOHN ALEXANDER LOW WADDELL, bridge engineer, died on March 3 at the age of eighty-four years.

DR. LOUIS C. SCHROEDER, associate professor of pediatrics at Cornell University Medical School, died on February 25. He was fifty-six years old.

DR. THOMAS BARNES FUTCHER, visiting physician at the Johns Hopkins Hospital, recognized for his work as diagnostician, died on February 25. He was sixty-seven years old and had been connected with the hospital since 1894.

THE Marconi Memorial Foundation, New York City, announces that contributions aggregating $30,000 for the erection of a monument in Washington to Guglielmo Marconi had been received, although the campaign to raise money for the project was not yet fully under way. A bill to authorize the erection of the monument has been introduced in Congress.

SCIENTIFIC EVENTS

THE IMPERIAL INSTITUTE

DEVELOPMENTS of the work of the Imperial Institute, South Kensington, which last year celebrated its jubilee, are described in the London *Times* in a summary of the annual report of the institute for 1937.

In a foreword to the report Sir Harry Lindsay, the director, discloses for the first time how narrowly the Imperial Institute escaped extinction during the economic depression, when Dominion contributions were withdrawn and in some cases Colonial grants were reduced. He states that if it had not been for the generosity of one or two private benefactors the institute would have been compelled either to curtail its activities even more drastically than it did or else to

close down altogether. In 1933–34, however, almost all the Colonial Governments agreed to double their existing rates of contribution, the United Kingdom Government substantially increased its support, and as a result of these efforts and of the resumption of contributions by the Union of South Africa, New Zealand and Newfoundland and the decision of the Government of Burma to support the institute, the position has been improved. Through the support of the Union Government of South Africa and a donation of £1,000 by Sir Robert Hadfield it has been possible to restore the staff of the mineral resources intelligence section nearly to full strength.

The exhibition galleries, the cinema and the Empire film library are referred to by Sir Harry Lindsay as representing the institute's activities in visual instruction in Empire affairs, and they have earned for it the title "An Empire Storyland." School parties formed the major part of the visitors to the galleries during the year. The galleries have been rearranged on a system which links the various Empire Courts into which they are divided in a sequence consistent with world geography. Each has its own color scheme; its contents comprise photographs, photographic transparencies, statuettes of Empire builders, dioramas and new types of exhibits that tell the story of the Empire's premier industries from the raw material of the producing country to the manufactured products of the world's markets.

The Empire film library, begun by the Empire Marketing Board, circulates to schools its own cinematographic romances of life, scenery and industries. Between the Empire film library, the cinema at the institute and the G.P.O. film unit, for which the institute acts as agent, the aggregate of the audiences to whom the films were shown in 1937 attained the record of 5,000,000, chiefly school children. The number of copies of films in the library is 1,300, and the number of borrowers has increased from 22,785 in 1936 to 24,600 in 1937.

The work of the mineral resources department has increased considerably. Technical inquiries totalled 1,101, an increase of nearly 19 per cent. over 1936, and the laboratory investigations involved the examination of 317 samples from 30 countries. The intelligence section of the plant and animal products department dealt with about 1,200 inquiries from over 40 empire countries.

THE REPRINTING OF HISTORICAL AND SCIENTIFIC BOOKS AND MONOGRAPHS

A SMALL committee, presided over by Professor B. Němec, met at Prague on December 3 and 4, to study the possibility of publishing old scientific works.

This question has been raised by Professor Němec, in the name of the Czechoslovak Research Council, and has been adopted as part of the plan of scientific work of the International Organization for Intellectual Cooperation, by the executive committee of the International Council of Scientific Unions, acting as a committee of scientific advisers.

This committee unanimously agreed that it would be desirable to publish a collection of manuscripts or works on the exact and natural sciences, printed copies of which are extremely rare or almost inaccessible. A collection of this kind would show the common origins of modern scientific culture and would be of great value to all interested in the historical development of the exact and natural sciences.

Considering the strictly international character of the undertaking the committee recommended that it be entrusted to the International Organization for Intellectual Cooperation. It was of the opinion that such a collection should not be confined to one branch of science alone and that it should embrace all the periods in the development of science since the Middle Ages. The committee further recommended that the publications might be divided into two series:

1. A series of facsimiles relating to very rare manuscripts or works containing engravings or illustrations indispensable for the value of such works.

2. A series of reprints of fundamental classical works in the development of the sciences, copies of which are extremely rare or no longer obtainable. In this series provision might also be made for the publication of manuscripts that have never been printed.

The committee suggests the publication in facsimile of the following manuscripts in the order given below:

1. "De Revolutionibus orbium caelestium," by Nicolas Copernic.

2. "De proprietatibus rerum," de Bartholomeus Anglicus. The committee was of the opinion that the publication in facsimile should be limited to the illustrations which appeared in all the editions. A summary of each chapter of the original work, with a biography of the author should accompany the illustrations.

3. "Micrographia," by Robert Hooke.

In addition, the committee suggests the reprinting of very rare works or the publication of hitherto unpublished manuscripts. It proposes the publication of the following works in the order given:

1. "New System of Chemical Philosophy," by John Dalton.

2. "Publication of a selection of letters from the scientific correspondence of Jean Hevellius, astronomer and selenographer." The greater part of this correspondence is at the Bibliothèque Nationale, Paris.

3. "Opuscula Botanitii argumenti," by Rudolph Camerarius.

4. "De solido intersolidum naturaliter contentor," by Nicolas Steno.

5. "Origin of Species," by Darwin. A reprint of the *first* edition (1859).

6. "Expériences pour servir à l'historie de la génération des animaux et des plantes," by Lazaro Spallanzani.

7. "Disquititio de sexu plantarum," by Linnaeus.

FLOOD CONTROL RESEARCH AT CORNELL UNIVERSITY

FLOOD control measures for the southern tier counties of New York State and the adjoining counties in northern Pennsylvania are under intensive study at Cornell University by the War Department, the School of Civil Engineering cooperating. Benjamin K. Hough, Jr., of the U. S. Army Engineering Corps, has a staff of 35 men working in Ithaca on problems of soil mechanics. A. N. Vanderlip with Professor Ernest W. Schoder and other members of the Cornell engineering faculty are conducting research in hydraulics. The War Department is making extensive use of the Hydraulics Laboratory of the College of Engineering and has erected on the campus a new soil mechanics laboratory, equipped with two carloads of apparatus from the abandoned Passamaquoddy Dam project in Maine.

Research is proceeding in two major directions: problems in channel improvement, construction of check dams and other water control measures; and studies of foundation conditions and suitable materials for earth embankments and earth dams where needed. The first important problem in the hydraulic group necessitated the construction of a scale model of the Chenango River through Binghamton, where disastrous floods occurred in 1935 and 1936.

The model, constructed in the Beebe Lake canal above the Hydraulics Laboratory and built to exact scale of 12 inches to 75 feet, has made possible studies of the Chenango River for two miles above its junction with the Susquehanna. The flow of water in the model is regulated in proper proportion to that in the river for its various flood stages and is measured and recorded very accurately for flood control study.

A serious difficulty has been to secure accurate data to guide the operation of the model. Few reliable records were made before the flood of July, 1935. The preliminary tests had to be run under three conditions: (1) with the river partly blocked by sections of the bridge, as immediately after the flood, (2) with the river partly blocked in a different way by contractors' trestles for the new bridge structure, and (3) with the river flowing freely under the new bridge. Now that the reliability of the model as an accurate reproduction of the river to scale has been established, each test still has to be done three times, with different levels of flow in the Susquehanna.

Careful experimental studies have shown the probable effects of a number of proposed channel improvements designed to lower the Binghamton flood stage at least a foot—a margin which would have had important beneficial effects during both recent floods.

Most of the dams and embankments to be constructed will be of earth. Hence the properties of the earth to be used assume great significance. Samples from various sites are under continuous scientific study. On the basis of these tests, army engineers are selecting sites and designing structures which will eventually control the flow of water through the entire Susquehanna Valley, and will, it is hoped, completely eliminate the danger of serious floods in the future.

WILD LIFE WEEK

PRESIDENT ROOSEVELT has set aside the week of March 20 to 26 as Wild Life Week. The week, sponsored by the General Wild Life Federation at the recent Baltimore meeting, will be devoted to raising funds for restoration work in all branches of wild life conservation.

The proclamation follows:

WHEREAS, One of the most important phases of the conservation of our natural resources is the protection and preservation of our wild life; and

WHEREAS, This is a work in which virtually our entire citizenship can participate wholeheartedly and enthusiastically, whether resident in the large metropolitan centers, with limited access to the great out-doors, or permitted to enjoy at first hand the wonders of nature; and

WHEREAS, The carrying into effect of any program for the conservation of our hereditary wild life—in the past seriously diminished and depleted by destructive exploitation and lack of proper understanding and sympathy—must enlist the support of all of our citizens if the mistakes of the past are to be avoided in the future in dealing with this important resource of incalculable social, economic, esthetic and recreational value:

Now, therefore, I, Franklin D. Roosevelt, President of the United States of America, do hereby proclaim and designate the week beginning March 20, 1938, as National Wild Life Week, and do earnestly appeal to all of our citizens first to recognize the importance of the problem of conservation of these assets in wild life, and then to work with one accord for their proper protection and preservation. To this end I call upon all citizens in every community to give thought during this period to the needs of the denizens of field, forest and water, and intelligent consideration of the best means for translating good intentions into practical action in behalf of these invaluable but inarticulate friends. Only through the full cooperation of all can wild life be restored for the present generation and perpetuated for posterity.

In Witness Whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

Done at the City of Washington this 14th day of

February, in the year of our Lord nineteen hundred and thirty-eight, and of the independence of the United States of America the one hundred and sixty-second.

FRANKLIN D. ROOSEVELT

Stamps bearing pictures of American wild animals and birds, designed by Jay N. ("Ding") Darling, cartoonist, already have gone on sale throughout the nation.

AWARD OF THE MEDAL OF THE NEW YORK ACADEMY OF MEDICINE

AT the stated meeting of the New York Academy of Medicine on the evening of March 3 the medal of the academy was presented to Dr. Béla Schick, discoverer of the Schick test in 1913, on the occasion of the twenty-fifth anniversary of the publication of his work on immunity in diphtheria. Dr. James Alexander Miller, president of the academy, made the presentation. He spoke as follows:

To you, Dr. Béla Schick, the Council of the New York Academy of Medicine has awarded the academy medal and upon this occasion I have the privilege of presenting this medal to you.

This is a well deserved honor.

Since you received your medical degree, in 1900, at the Karl Franz University at Graz, Austria, you have devoted your energies not only to clinical medicine but also to medical investigation and to teaching.

As early as 1905 you, with Clemens von Pirquet, also a distinguished pupil of Theodore Escherich, published the classical monograph—*Serumkrankheit*. This not only gave the first description of serum sickness, but also established fundamental principles of allergy. In 1912, with Escherich, you published the celebrated clinical monograph on scarlet fever. You had meanwhile promulgated the idea that post-scarlatinal diseases were allergic in nature. This is now a firmly established fact, of wide significance.

You have also made important studies of the nutrition of the newborn, of infantile tuberculosis, of metabolism in infectious diseases, as well as of other subjects.

It was in 1913 that you published the discovery which has given you the widest fame—the reaction which so justly carries your name. This was no chance observation, but was the result of careful studies carried on over a number of years.

Through this discovery you made it possible to determine who is and who is not susceptible to diphtheria, and this laid the basis for the present-day effective campaign of prevention against this dreaded disease. Your place is, therefore, amongst the great benefactors of mankind.

It is an honor to present to you the Medal of the New York Academy of Medicine upon this date, made notable by the fact that it is the twenty-fifth anniversary of the announcement of the Schick reaction.

Dr. Schick was born in Boglar, Hungary, on July 16, 1877, and was graduated from the medical school at Graz, Austria, in 1900. Since 1923 he has been pediatrician-in-chief at Mount Sinai Hospital. He is also clinical professor for diseases of children at Columbia University, pediatrician in chief at the Sea View Hospital and consulting pediatrician at the Willard Parker Hospital and the New York Infirmary for Women and Children.

SCIENTIFIC NOTES AND NEWS

THE Kelvin Medal Award Committee has awarded the Kelvin Medal for 1938 to Sir Joseph J. Thomson, master of Trinity College, Cambridge, in recognition of the eminent services he has rendered to engineering science. The presentation will be made by Lord Rayleigh at the Great Hall of the Institution of Civil Engineers on May 3.

THE University of Oxford will confer the degree of doctor of medicine on four newly appointed Nuffield professors. They are H. W. B. Sairns, R. R. Macintosh, J. Chassar Moir and J. A. Gunn, Nuffield professors of surgery, anesthetics, obstetrics and gynecology and therapeutics, respectively.

AT a special convocation on February 21 at the University of Manitoba, presided over by Sidney E. Smith, president of the university, the doctorate of laws was conferred on Dr. E. V. McCollum, professor of biochemistry and head of the department at the School of Hygiene and Public Health of the Johns Hopkins University, in recognition of his contributions to medical science. Premier John Bracken represented the Manitoba Government at the ceremony.

DR. HOWARD A. KELLY, professor of gynecology, emeritus, at the Johns Hopkins University, the only surviving member of the group that was instrumental in the founding of the Medical School, celebrated his eightieth birthday on February 20.

A DINNER in honor of Howard S. Warren, director of the protection development department of the Bell Telephone Laboratories, was given by his associates on March 2 in observance of his sixty-fifth birthday. On this occasion he was presented with a bronze desk set. Mr. Warren retires at the end of the present month, having served the Bell Telephone System for thirty-nine years.

DR. W. A. SETCHELL, professor of botany, emeritus, at the University of California, has been elected a foreign member of the Royal Society of Science and Arts of Göteborg, Sweden.

DR. ULYSSES P. HEDRICK, who retired as director of the State Agricultural Experiment Station at Geneva, N. Y., on January 15, has been elected honorary president for life of the New York State Horticultural Society, of which he is a past president.

AMONG honorary members elected on February 22 by the British Institute of Civil Engineers are Sir Robert Elliott-Cooper, consulting engineer and senior past president of the institute, and Sir Frank Smith, secretary of the Department of Scientific and Industrial Research.

THE Cesare Lombroso prize for criminal anthropology has been awarded to Dr. Luigi Vervaeck, director of the service of criminal anthropology in Belgium.

DR. FRANZ VOLHARD, professor of internal medicine at Frankfurt, has recently been awarded the Billroth medal by the Medical Association of Vienna.

WHEELER MCMILLEN, an authority in agriculture and the editorial director of *The Country Home,* has been elected to succeed the late Francis P. Garvan as president of the National Farm Chemurgic Council. Willard H. Dow, president of the Dow Chemical Company, has been elected vice-president representing industry.

THE Metropolitan Dairy Technology Society recently elected the following officers for the ensuing year: Dr. J. H. Shrader, *president;* Dr. C. H. Kimberly, *vice-president;* Dr. O. F. Garrett, *secretary-treasurer,* and D. F. Snyder, *sergeant-at-arms.* The society meets on the fourth Tuesday evening of every month in the McGraw-Hill Building, New York City.

THE council of the Royal Society has appointed Dr. M. C. G. Israels, assistant director of the department of clinical investigation in the Manchester Royal Infirmary, to a Foulerton research fellowship. Dr. Israels proposes to work on the nature and causes of blood disorders and allied conditions.

ACCORDING to *Nature,* Ramsay memorial fellowships for the year 1937–38 have been awarded to: A. E. Alexander, a British fellowship of £300, tenable for two years, at the University of Cambridge; T. P. Hughes, a British fellowship of £300, tenable for one year, at the University of Cambridge; Dr. E. de Salas, a fellowship of £300, tenable for one year, at University College, London; Dr. E. C. Stathis, a Greek fellowship, tenable at University College, London; Hazime Oosaka, a Japanese fellowship, tenable for two years, at University College, London; Dr. M. C. F. Beukers, a Netherland fellowship of £300, tenable for one year, at the Imperial College of Science and Technology, London; Dr. J. J. Hermans, a Netherland fellowship, tenable at University College, London. The Glasgow fellowship held by Dr. R. R. Gordon at University College, London, has been renewed.

The British Medical Journal reports that the following awards have been made to medical men from the fund placed at the disposal of the Secretary of State for the Colonies by the trustees of the Carnegie Corporation for the purpose of enabling selected officers of the Colonial Service to undertake special courses of study: Dr. C. J. Austin (medical superintendent, Central Leper Station, Makongai, Fiji), for the study of leprosy in Egypt, India, Malaya and the Philippine Islands; Dr. W. B. R. Jones (medical officer, Nevis, Leeward Islands), for a course in general surgery at the University of Edinburgh; Dr. A. H. Lowther (Malayan Medical Service), for studies in ophthalmology in Europe, India and Egypt.

THE Rockefeller Foundation of New York has continued for another five years its support of the radiobiological investigations of Professors A. Kluyver, of Delft, and L. S. Ornstein, of Utrecht.

DR. RICHARD E. SCAMMON, "distinguished service professor" in the Graduate School of the University of Minnesota, who retired as dean of the medical sciences in 1935, recently was reported incorrectly in SCIENCE as having been appointed chairman of the Minnesota Drainage Basin Committee. W. W. Horner is chairman of this committee and Dr. Scammon is chairman of the Minnesota representatives on the Drainage Basin Committee.

THE fourth International Leprosy Conference will be held in Cairo, Egypt, from March 21 to 31, under the auspices of the International Leprosy Association. The *Journal* of the American Medical Association reports that the following delegation will represent the United States: Drs. Hermon E. Hasseltine, Carville, La., *chairman;* Victor G. Heiser, New York, president of the International Leprosy Association; Herbert W. Wade, Culion, P. I., medical director of the Leonard Wood Memorial (American Leprosy Foundation) and editor of the *International Journal of Leprosy;* Jose Rodriguez, of the Philippine Health Service, Manila, P. I.; James A. Doull, of Western Reserve University; George M. Saunders, director of the epidemiological department of the Leonard Wood Memorial; Perry Burgess, New York, president of the Leonard Wood Memorial, and Emory Ross, general secretary of the American Mission to Lepers. The group sailed from New York on March 1.

DR. LAURENCE E. DODD, associate professor of physics at the University of California at Los Angeles, has returned from Europe, where he spent six months' leave of absence. During this time he visited universities, technical institutes, research institutes, research

laboratories and libraries in England, France, Germany, Switzerland, Austria, Belgium and Holland.

DR. HERBERT S. GASSER, director of the Rockefeller Institute for Medical Research, New York, delivered the eleventh William Snow Miller Lecture on March 8 at the University of Wisconsin under the auspices of the Phi Beta Pi Medical Fraternity and the Medical Society of the University of Wisconsin. He spoke on "The History of Electrophysiology." Dr. Miller will be eighty years old on March 29.

DR. WENDELL M. STANLEY, associate member of the Rockefeller Institute for Medical Research at Princeton University, will deliver the sixth Harvey Society lecture of the current series at the New York Academy of Medicine on March 17. Dr. Stanley will speak on "The Isolation and Properties of Tobacco Mosaic and Other Virus Proteins."

DR. EDWARD L. THORNDIKE, director of the division of psychology of the Institute of Educational Research of Teachers College, Columbia University, lectured on March 9 before the American Academy of Arts and Sciences. His address was entitled "Great Abilities: their Causation, Discovery and Utilization."

DR. ROBERT CHAMBERS, research professor of biology at New York University, lectured on March 5 before the Royal Canadian Institute, Toronto, on "The Living Cell as an Architectural Unit of the Body." He also lectured on March 7 before the Aesculapian Society, at Queen's University, Kingston, on "Cellular Activities."

DR. A. STAMPAR, formerly director of health of Yugoslavia, delivered the De Lamar lecture on hygiene at the Johns Hopkins School of Hygiene and Public Health on March 3. The subject of the lecture was "International Health Work."

DR. WINFRED OVERHOLSER, recently appointed superintendent of Saint Elizabeth's Hospital, Washington, D. C., delivered the Smith-Reed-Russell lecture at the School of Medicine, George Washington University, on February 24. A large luncheon in honor of Dr. Overholser was given by Dean Earl B. McKinley at the Cosmos Club following the lecture at which faculty members, representatives of the medical services of the Army, Navy and Public Health Service and invited guests from Baltimore and New York attended. Announcement of the appointment of Dr. Overholser to fill the chair of psychiatry, vacated recently by the death of Dr. William Alanson White, was made. He will assume his duties as professor of psychiatry and executive officer of the Department of Psychiatry with the opening of the fall session in September, 1938.

PROFESSOR EDWIN GRANT CONKLIN, of Princeton University, executive vice-president of the American Philosophical Society, will speak at the Founders' Day celebration of Randolph-Macon Woman's College on March 12, when the recently completed Fernando Wood Martin Science Building will be dedicated. Dr. Mary Sherrill, professor of chemistry at Mount Holyoke College, South Hadley, Mass., an alumna, will also speak at the dedicatory exercises. The building, a memorial to the late Fernando Wood Martin, who was the first professor of chemistry at the college, has been erected at a cost of $200,000. It was made possible by a gift from the General Education Board of New York, supplemented by contributions from faculty, alumnae, students and friends.

A SYMPOSIUM entitled "The Impact of Science on Every-day Life" will be held at the Harvard Club of New York City on March 11. President Conant will open the program by outlining the subject and will close it with a talk on "A Common Denominator." The other speakers and their subjects will be: Dean Wallace B. Donham, of the Graduate School of Business Administration, "The Front Office Watches the Laboratory"; Professor George W. Pierce, director of the Cruft Memorial Laboratory, "The Laboratory Works On, but Ponders"; Professor Harlow Shapley, director of the Astronomical Observatory, "A Telescopic View." President Conant will act as moderator in a question period following the symposium.

A MATHEMATICAL colloquium, similar to those held in 1926, 1930 and 1934, will be held at the University of St. Andrews, Scotland, from July 4 to July 15, under the auspices of the Edinburgh Mathematical Society. Short courses of lectures will be given on topics of pure and applied mathematics. Members will have the opportunity of attending a meeting of the Royal Society of Edinburgh on July 4. Those wishing further information in regard to the colloquium should apply to the Secretary, Edinburgh Mathematical Society, 16 Chambers Street, Edinburgh 1.

THE department of geology and geography at Smith College is sponsoring a series of lectures and conferences during the second semester of the current academic year. The series was opened on February 8 by Wallace W. Atwood, Jr., of Clark University, who spoke on "The Physiographic History of the Rocky Mountain Region." On March 2 Sydney H. Ball lectured on "The Diamond." A. C. Swinnerton, of Antioch College, will discuss "The Problems of Limestone Terranes" in conferences to be held on April 7 and 8. The series will be concluded on April 26 by Richard Foster Flint, of Yale University, who will present the results of four seasons of field research on the "Tertiary and Pleistocene Geology of the Columbia Plateau."

DISCUSSION

THE SPEED OF THE DEER FLY

ABOUT ten years ago, an editorial in *The New York Times*, in commenting on a new seaplane speed record of something over 300 miles per hour warned man not to be too boastful of his accomplishments, since the deer fly has a speed of 700 miles per hour. This speed, nearly that of sound, seemed to me so fantastically high that I was led to make some rough mental calculations, by dimensional reasoning, comparing the fly with a Zeppelin as to diameter and speed and fuel consumption. I found that the fly would have to consume his own weight of fuel every few minutes or so to supply the necessary power.

I was curious also regarding the source of the data and the nature of the measurements, for the methods of measuring the velocities of revolver bullets are not easily applicable to deer flies.

About a year ago there was an editorial in a Schenectady newspaper giving the speed of the deer fly as 800 miles per hour. Since then I have met many people who have seen similar citations in various publications, so I believe the story is going the rounds over the whole country.

I was therefore interested in a 2-page diagram in the *Illustrated London News*, January 1, 1938, giving the comparative speeds attained by man and by animals, fish, etc. The female deer fly was credited with 614 miles per hour, while for the male the record was 818 miles per hour.

On the next page there was a photograph entitled, "The speed champion of the world, capable of outstripping sound: a Deer Botfly (*Cephenomyia Pratti* Hunter)." Under this was a reference to the source of the data that I had long been hoping to find:

> Writing in the *Journal* of the New York Entomological Society, Dr. Charles H. T. Townsend, who has studied insects, and Cephenomyia in particular, for many years, states "On 12,000 foot summits in New Mexico I have seen pass me at an incredible velocity what were certainly the males of Cephenomyia. I could barely distinguish that something had passed—only a brownish blur in the air of about the right size for these flies and without a sense of form. As closely as I can estimate, their speed must have approximated 400 yards per second."

It should be noted that the 400 yds/sec is 818 m/hr, while 300 yds/sec is 614 m/hr.

The article on "Ballistics" in the Encyclopedia Britannica, 1929 Edition, vol. 2, p. 1003, gives for the resisting force (drag) acting on a projectile of diameter d, moving with the velocity v:

$$R = \rho d^2 v^2 f$$

where ρ is the density of air, and f is a numerical factor that depends on the shape of the projectile and on the ratio v/v_o where v_o is the velocity of sound. This factor increases rapidly when the velocity approaches that of sound. For the speed of 818 m/hr (3.7×10^4 cm/sec) $f = 0.20$, for the best projectiles with sharp points and rises to 0.50 for cylindrical projectiles with flat heads. The deer fly has a very flat head, so that if we choose $f = 0.25$ we shall certainly be taking too low a value. If we take $d = 0.5$ cm for the body of the fly and neglect the resistance of the wings we shall again be taking a lower limit. The equation thus gives:

$$R = 1.0 \times 10^5 \text{ dynes}$$

or a force equal to the weight of 100 grams. A check on this result was obtained from equations of entirely different form in the "Handbuch der Physik," vol. 5, p. 311 (1927).

Thus the wind pressure against the head of the fly amounts to about 8 pounds per square inch or more than half an atmosphere, probably enough to crush the fly. This force if unopposed would give an acceleration of 500 times gravity, taking the weight of the fly to be 0.20 grams (density, 1., length 1. cm, diameter 0.5 cm).

The power consumption needed to maintain this velocity of 818 m/hr would be 3.7×10^9 ergs/sec or 370 watts or about one-half horse power—a good deal for a fly!

A man weighing 200 pounds and in good training can climb about 10,000 feet in a day, but he will eat at least 3 pounds of dry food and 2 pounds of water. The man develops 1.0 horsepower-hours of work or 2.7×10^{13} ergs and the food consumption amounts to 8×10^{-11} grams per erg. The insect can not do much better than this, since even man has a rather high thermodynamic efficiency.

On this basis the insect, to deliver 370 watts, must consume 0.31 grams per sec or 1.5 times his own weight of food each second!

The quoted statement of Dr. Townsend is obviously a mere rough estimate, which can not justifiably be used to establish a world record. It is of interest to determine the speed of an object the size of a deer fly which would appear as "a barely distinguishable blur in the air." For this purpose I took a short piece of solder about 1 cm long and 0.5 cm diameter and tied it about its middle to one end of a light silk thread, holding the other end in my hand. With lengths of thread of from 1 to 3 feet it was easily possible to swing the weight in a circle in a vertical plane at the rate of 3 to 5 rotations per second (timed with a telechron clock). In this way speeds from 13 to 64 miles per hour were produced.

Observations in a room, with a brightly lighted white ceiling as background, showed that at 13 miles per

hour (580 cm/sec) the "fly" was merely a blur—the shape could not be seen, but it could be recognized as a small object of about the correct size.

At 26 m/hr (1,150 cm/sec) the fly was barely visible as a moving object. At 43 m/hr (1,920 cm/sec) it appeared as a very faint line and the direction of rotation could not be recognized. At 64 m/hr (2,900 cm/sec) the moving object was wholly invisible.

That even a black object of this size moving at 64 m/hr should be invisible is also apparent from the fact that in 1/20th second (about the shortest time that the eye can recognize) the object moves 150 cm, and thus if it has a length of 1. cm the average intensity of the light along the 150 cm section of its track is decreased by only 0.7% by the presence of the object. Even under steady conditions in a photometer intensity differences of less than 1% are not distinguishable.

The description given by Dr. Townsend of the appearance of the flies seems to correspond best with a speed in the neighborhood of 25 m/hr.

In the Adirondacks I have been surprised by the swift flight of insects which I have been told were deer flies. These flies often strike one's bare skin with a very noticeable impact, far greater than that of any other insect I have met. However, if the speed were 800 m/hr and the fly on striking should be stopped within 1. cm it would come to rest in about 55×10^{-6} sec, and during this time there would be a force of 1.4×10^{-8} dynes or 140 kg (310 pounds). It is obvious that such a projectile would penetrate deeply into human flesh.

The appearance of the moving lead weight on the thread at 25 m/hr seems to agree roughly with my recollections of the deer flies.

The power requirement of a fly at 25 m/hr ($f = 0.08$) would be 0.0034 watts, which would involve a food consumption of about 5% of the fly's body weight per hour, a value which could not well be greatly exceeded if the flies are to fly over 12,000 foot mountain peaks.

Thus a speed of 25 miles per hour is a reasonable one for the deer fly, while 800 miles per hour is utterly impossible.

IRVING LANGMUIR

RESEARCH LABORATORY,
GENERAL ELECTRIC COMPANY,
SCHENECTADY, N. Y.

THE BAXTER METEORITE

AUTHENTIC cases of meteorites striking buildings are rare. W. J. Fisher was able to find only two records for the whole of North America up to 1933. One of these—a stone of the New Concord fall—was said to have "struck a barn." The other, the Kilbourn stone, Wisconsin, penetrated the roof of a barn and a one-inch hemlock board floor four feet below the roof.

Recently Mr. Frank Clay Cross, who cooperates with the American Meteorite Laboratory, received from Mrs. J. W. Jackson, of Point Lookout, Missouri, a small stony meteorite which was said to have broken through the roof of a house in 1916. The meteorite was examined and proved to be an almost complete individual weighing 611 grams. Its fresh appearance was consistent with the report; but it seemed to us peculiar that an event of this nature should not have been reported at an earlier date. Rev. J. C. Nininger, brother of the writer, who lives some sixty miles from Point Lookout, was dispatched to the location to make a thorough investigation. He found the report easily verified by several neighbors and by a local newspaper account, which gave the date as January 18, 1916, at about 9:00 A.M. The location was near Baxter in Stone County, where the Jacksons lived at the time. Mrs. Frank Jackson, mother of J. W. Jackson, was in the house at the time of the fall and her son was at the barn about sixty yards away. He had heard the noise of the meteorite and had seen the light through a low-hanging cloud. He saw the stone strike the roof.

The meteorite, after passing through the roof, struck a log joist which evidently checked the fall. It lodged in the attic. The Jacksons removed boards from the gable in order to get at the stone, which they had kept ever since.

This will be known as the Baxter meteorite. It has been purchased for the Nininger collection. Casts have been made of the specimen preparatory to sectioning a small portion of it for study.

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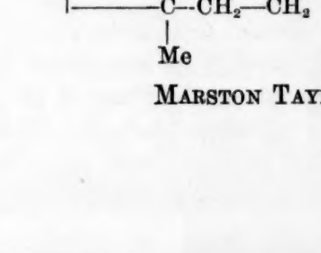
THE SYNTHESIS OF FICHTELITE

IN redrafting the formulas for our article on fichtelite which appears on page 196 of the issue of SCIENCE for February 25, I am sorry to say that there was a slight error made in formulas (I) and (II). These formulas should have been given as follows:



(I)

(II)

MARSTON TAYLOR BOGERT

THE PRONUNCIATION OF BACTERIOPHAGE

IN view of the fact that in many places *phage* by itself and in its combinations, as in *bacteriophage,* is being pronounced *fäzh* (*a* as in *art*), I think it not out of place to call attention to the fact that Webster's International Dictionary, 1935 edition, gives the pronunciation as *fāj*; and Dr. Frank Vizetelly for the Standard Dictionary states, "The pronunciation of *phage* is *fēj*—*e* as in *prey.*"

C. J. ELMORE

WILLIAM JEWELL COLLEGE

REPORTS

ANNUAL TABLES OF CONSTANTS AND NUMERICAL DATA

NOW is the time for all good chemists, and physicists, too, to come to the aid of international effort for a permanent solution of the problem of numerical data in the physical sciences. Ten years ago, at a very heavy cost and with the generous financial support of several foundations, scientific societies, research institutes and many industrial organizations, the United States put forth her effort in the compilation of International Critical Tables. That effort met a generous response on the part of scientists, and several thousand sets of the eight volumes eventually found distribution among the scientific public. Daily, since then, these tables have been used, and citations from them, in the scientific literature here and abroad, are a constant feature, month by month. They have thus justified the time and money and effort which their preparation entailed.

International Critical Tables do not, unfortunately, supply a permanent solution of the problem of physical and chemical data. Newer and better data are constantly replacing the older data. The critical judgment of a decade ago is not necessarily the best or a final judgment. Nor does science stand still. Looking back over a decade of scientific work we see the branches of modern science that were not known when I.C.T. were published. If we think, for example, of deuterium chemistry with all the intensive developments of the last five years, with its effects on organic chemistry, on reaction kinetics, on biochemistry, on nuclear physics, on molecular structure, Raman spectra, none of these newer data of our sciences are to be found in I.C.T. Think, too, of the neutron, the positron, the proton, the deuton and the influence they have exercised on chemistry and physics, with new isotopic species, radioactive and non-radioactive, and the data that have correspondingly accumulated. New techniques in thermodynamics, with entropy data from spectroscopic sources, from low temperature heat capacity measurements, improved techniques of thermochemical measurement by combustion, hydrogenation and electromotive force data—all these have advanced at an accelerated pace in these last ten years; and, what is more important, the application of these data to important industrial developments has been correspondingly intensified. Ten years ago, for example, the application of thermodynamics in the petroleum industry was necessarily of the most elementary nature. To-day it is literally true that the modern aviation fuel will be brought to a higher pitch of perfection, necessary to modern needs, thanks to the entropy, heat capacity and thermochemical data recently accumulated by newer approaches, experimental and theoretical. X-ray analyses of industrial materials, electron diffraction studies of organic compounds, dielectric constants and molecular spectra, all are yielding data on bond distances and bond energies that make our knowledge of molecular structure more intimate and more profound. To keep I.C.T. abreast of this pace of progress, it would require a new edition or new supplements at least every five years. The organization that brought I.C.T. into existence no longer exists. It can not be reestablished without a prohibitive cost. We are forced, therefore, to inquire how, most efficiently, and with the least delay, it can be replaced.

The opportunity to achieve this objective is at hand, and it is imperative that the most serious consideration should be given to the steps necessary to a permanent solution of the problem of numerical constants and data, continually up-to-date. The International Union of Chemistry and the International Council of Scientific Unions have, for many years already, sponsored the publication of Annual Tables of Constants and Numerical Data. An International Commission with a managing board, with headquarters in rue Pierre Curie in Paris, has supervised this work. The aim was originally to publish, each year, the accumulated data of the preceding year in science. The Great War and financial difficulties caused this effort to lag. The Annual Tables have been several years behind schedule. Thanks largely to the generosity of the French Government, with additional financial assistance promised but not yet implemented from other national sources, a strenuous effort has been made in the last two years to bring Annual Tables up to date. Volume XI, Part I, of these tables, just about to appear (McGraw Hill and Co., distributors for U.S.A. and Canada), embodies material for 25 sections of data from the years 1931–34 and material for a few sections of data from the years 1931–36. Volume XI, Part II, and Volume XII will complete the data in the remaining fields up to 1936. These volumes, in active preparation, should appear before the end of 1938 or early in 1939.

It may well be that the delays in publication, which these volumes aim to resolve, will prove ultimately to be a blessing in disguise. The collection of data, covering several years of work in one field, has led the publishers in Paris to offer for sale individual sections, in monograph form, of the volumes now appearing. These units can be sold separately, at a price of $1 to $2, and are thus accessible to workers, in special fields at practicable prices, who could not be expected to procure the complete volumes of data. This separate publication of individual units also enhances the utility of Annual Tables to libraries and their users. Thus, by the purchase of each volume as published and each monograph as it appears, a library can always reserve the volume for library use, but the individual monographs can be taken out on loan to the laboratories and offices, where their special data can be thus continuously accessible to a worker in that field.

Of the data in Volume XI, Part I, about to appear, we can signalize, by way of exemplification, the following of ten separate monographs.

1. Deuterium and Deuterium Compounds (1932–36) by G. Champetier, 79 pp.
2. Dielectric constants and Dipole moments (1931–34) by P. Debye and H. Sack, 66 pp.
3. Free Energy, Heat Content, Entropy and Activity (1931–34) by J. Gueron and J. P. Mathieu, 69 pp.
6. Vapor Pressure, Boiling Points and Gas Laws (1931–34) by W. P. Jorissen, P. C. van Keekem and W. H. Keesom, 65 pp.
9. Electromotive Forces; Oxidation-Reduction Potentials (1931–36) by H. S. Harned and G. Akerlöf, 45 pp.
10. Thermochemistry (1931–34) by W. A. Roth, 82 pp.

Of Volume XI, Part II, we can note the forthcoming publication of monographs on

Molecular Spectra (1931–36) by V. Henri.

15. Raman Effect (1935–36) by M. Magat, 146 pp.
21. Entropy, Heat Content, Free Energy (1935–36) by J. Gueron and J. P. Mathieu, 42 pp.
16. Light Scattering, Reflexion and Refraction (1931–36).
22. Electrolytic and Chemical Equilibria (1931–36) by H. Griffith A. McKeown and W. S. Shutt, 67 pp.

Acting on an inquiry addressed to it by the American Committee, the managing board has worked out a program which will permit the retention of the monograph idea and at the same time yield annually one volume of Tables of Constants. At the present time there are fields in which research is busy, numerical material abundant and change rapid. This is, for example, the case, at the present time, for nuclear physics, Raman spectra (see Monograph 15 above), dielectric constants, possibly thermochemistry and kinetics. Let us call such sections A. For many other sections, publication once in four years is adequate to collate the available material. The proposal now under study comprises the publication of one volume each year. In alternate years the material (A) which is accumulating rapidly, and covering two years only of data, will be issued. The other years will be employed in publishing, each alternate year, half of the sections, say B and C, in which pressure of new data is not so great. A four-year sequence would therefore be A,B,A,C, which would then repeat itself indefinitely.

This new proposal, if adopted, can lead to an enormous increase in the value of Annual Tables. It will solve the problem of keeping International Critical Tables up-to-date. It simplifies the problem of using such tables, since the newer data in the less busy sections can be covered with one fourth the labor involved in using the Annual Tables of former years. The data in the busy sections will never be more than two years behind publication, which is as it should be in busy fields. The new scheme solves a very difficult editorial problem associated with the older method of conduct of the tables, where one or two dilatory contributors or a contributor unable to complete an assignment due to sickness could hold up a complete volume indefinitely. The new arrangement would diminish such a risk to a fraction of the earlier one by such a division of sections over a period of four years. The new scheme would also diminish the valueless material that inevitably must creep into data published annually. A more critical survey of available data is possible when four years of data are simultaneously examined by those compiling the material.

Should such a program meet with approval by scientific men here it should be put into effect immediately. The years from 1939 to 1942 are transition years in which the project can be put into effect due to the present status of the Annual Tables as already outlined in a preceding paragraph. The plan is consistent with the monograph scheme, which should become the central and most promising feature of Annual Tables for the individual scientist. The Monographs permit the publication of data as ready, with the minimum of delay; the volumes provide the libraries with the same data in collected and permanent form.

Given the support of American science to this proposal, it is certain that a large measure of enthusiastic support can be secured internationally. It is probable that the scheme outlined above could have been put into effect at an earlier date had American cooperation on this basis been assured. Some financial aid for the project in its new form will be needed during the initial years. American research institutions, industrial organizations and the various foundations can reasonably be looked to for such support. The National Research Council will have the project under consideration during their spring meetings. It is to be hoped that such consideration can be based upon the ex-

pressed views of our leading scientific men. The Committee of Enquiry on Annual Tables, set up by the Division of Chemistry and Chemical Technology, is ready to transmit such views to the Research Council. All communications should be addressed to the writer as chairman of the committee at Frick Chemical Laboratory, Princeton, N. J. All such communications will receive the most earnest consideration of those who are charged with the responsibility of securing a solution of this most important problem for the future of research, both scientific and industrial.

HUGH S. TAYLOR,
Chairman, Committee of Enquiry on Annual Tables, National Research Council

SPECIAL ARTICLES

ON THE ORDER OF RELATIVE GROWTH INTENSITIES

IT has been shown for a wide variety of data that the equation, $y = bx^k$, is a general expression for the relation between a part (y) and the whole (x), as the organism increases in size. While this relative growth function can be regarded only as an empirical approximation, yet the approximation is perhaps close enough in many cases to warrant comparing relative growth intensities from the values of k. In a study of relative growth in *Notonecta undulata*, a common back-swimmer, 72 individuals were followed through their development from egg to adult.[1] Measurements taken at the six instars allow an estimate to be made of the true ontogenetic relative growth constants for the individual as well as for the average. From the average measurements it is found for the females, when leg-length (y) is taken against body-length (x), that the values of k for the first, second and third legs are 1.074, 1.069 and 0.948, respectively. Similar values of k for the males are 1.013, 1.012 and 0.908 for the first, second and third legs, respectively. There is a regular antero-posterior gradient, but this is perhaps misleading in the light of the results obtained when the individuals are studied separately. Among the females there were 20 which showed a regular antero-posterior growth gradient. The average values of k for these 20 animals are 1.092, 1.047 and 0.955 for the first, second and third legs, respectively. There were 15 females which showed the high point of the gradient in the middle; their average values of k are 1.046, 1.093 and 0.950 for the first, second and third legs. Among the males 17 showed a regular antero-posterior gradient. Their average values of k are 1.046, 0.997 and 0.916 for the first, second and third legs. The remaining 18 males showed a gradient with high point in the middle; the average values of k are 0.991, 1.048 and 0.904 for the first, second and third legs. While the general level of the gradient is higher in females, yet the difference between the high and low points of the gradient is about the same in both sexes. The average difference with its probable error for all 72 individuals, which include several aberrant specimens, is 0.135 ± 0.002. Although the order of relative growth intensities differs among the individuals, there is an exceptionally high degree of constancy in the relation between the high and low points of the gradient.

Data on the length of the three distal segments of the legs have been used to get a knowledge of the growth gradient within the legs. The results show that the high point of the gradient is represented by the tibia in the first leg and by the femur in the second and third legs. Here again the gradient is uniformly at a higher level in the females. The k-values from the average measurements for the femur, tibia and tarsus of the first leg against body-length are 1.066, 1.144 and 1.028 for females; and for males 0.971, 1.101 and 0.945. Corresponding figures for the homologous segments of the second leg are 1.114, 1.059 and 1.056 for females; and for the males 1.060, 1.013 and 1.010. For the third leg similar values are 1.141, 0.946 and 0.742 for females; and for males 1.104, 0.924 and 0.743. The difference between the high and low points of the gradient in the first leg is 0.116 for the females and 0.156 for the males. Similar values for the second leg are 0.058 and 0.05; and for the third leg 0.399 and 0.361. These values in the neighborhood of 0.37, 0.14 and 0.05, which give the difference in relative growth intensities in the several cases, are approximately the reciprocals of e, e^2 and e^3, which are 0.368, 0.135 and 0.0498, respectively. It was pointed out above that the average difference between the high and low points in the gradient for leg-growth along the thorax is 0.135. Are these relations between relative growth intensities and negative powers of e merely a curious coincidence or are they another instance of nature playing the mathematician? But in any case, the main point of the present note is to call attention to the problem which exists in regard to the order of relative growth intensities at the different levels in the gradient that are marked for us by the parts of the organism, and to point out that that order may differ in the individual from that which is found when average measurements are used for the determination.

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[1] The data were collected by Dr. L. B. Clark, of Union College, whom I wish to thank for generously allowing me their use for the present note.

PHOTOSENSITIVE PIGMENTS FROM THE RETINA OF THE FROG

THE recent spectrophotometric demonstration by Wald[1] of a light-sensitive pigment from the retina of the chicken whose absorption spectrum resembles the chicken bright visibility curve, is the first direct evidence of the presence of a photosensitive substance in the cones. Since the chicken retina contains cones predominantly and differs in this respect from the retinas of many vertebrates, it seemed worth while to look again[2] for a cone pigment in the retina of the frog, whose rod-cone population is more nearly like that of man.

The retinas were treated as described earlier[3] and extracted with a 2 per cent. digitalin solution (Eimer and Amend, Digitalin, "cryst.", G 57). All operations were performed in very dim red light containing no wave-lengths shorter than 640 mμ. About 10 frogs were used for each ml of extractive.

The absorption spectrum of the solution as prepared, and buffered at pH 9.0, was measured in a depth of 2 cm, from 440 mμ to 650 mμ, using Shlaer's photoelectric spectrophotometer.[4] The solution was then exposed for 30 minutes to extreme red light, obtained with a 100 watt lamp at a distance of 6 inches, and a Wratten filter, No. 88, which transmits only above 680 mμ. After again measuring the spectrum another thirty-minute exposure was given and a third spectrum

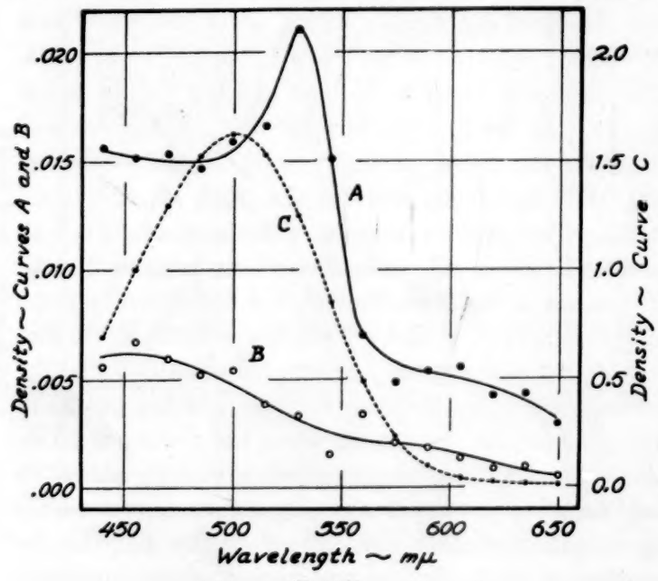

FIG. 1

recorded. Finally the solution was illuminated for ten minutes with white light and measured a fourth time.

The figure is from an experiment typical of several. Curve A results when the absorption spectrum of the solution after the first exposure is subtracted from that of the unexposed solution. This difference curve represents a light-sensitive substance or substances distinctly different from visual purple. The substance is so sensitive that even the monochromatic measuring light of the spectrophotometer causes some decomposition. Consequently, curve A may not describe exactly the absorption spectrum, but the true maximum may be farther toward the red than 530 mμ. Refinements in the procedure are necessary before its exact position can be established.

Curve B is the difference in density caused by the second exposure to red light. Practically all the substance with maximum absorption at 530 mμ disappeared during the first exposure; a further proof that it was not visual purple.

It is possible that more than one photosensitive pigment may be represented by curves A and B. On the basis of human color vision theory[5] one might expect three different substances from the cones if the frog retina resembles the human.

Curve C shows the difference in density that occurred during the ten-minute exposure to white light. This is the typical absorption spectrum of visual purple. It is significant that its concentration is considerably greater than that of the material represented by curve A, which confirms the prediction made by Hecht[5] from considerations of rod and cone sensitivity in the human eye.

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GENERAL MUSCULAR HYPERTROPHY INDUCED BY ANDROGENIC HORMONE

IN the guinea pig, the temporal muscles show a pronounced difference in size in the two sexes. In the adult female, they are comparatively small and flat; in the adult male they are much larger and can be felt as distinct protuberances over the upper part of the skull surface. This difference between the two sexes can be quite readily recognized in the normal adult animals.

In the course of experiments with gonadotropic hormone (Follutein), the temporal muscles of adult female guinea pigs underwent considerable hypertrophy. Injections of adequate amounts of gonadotropic hormone in such adult female animals over a period of several weeks resulted in an enlargement of the temporal muscles; they became rounded and protuberant much as in the normal adult male. This change was gradual and progressive and depended upon dosage and duration of treatment.

A survey of the various muscles in the treated animals showed that the induced growth was not limited

[1] G. Wald, *Nature*, 140: 545, 1937.

[2] W. Kühne, "On the Photochemistry of the Retina and on Visual Purple," Macmillan and Company, London, 1878 (see especially page 22).

[3] S. Hecht, A. M. Chase, S. Shlaer and C. Haig, SCIENCE, 84: 331, 1936.

[4] S. Shlaer, *Jour. Opt. Soc. Amer.*, 28: 18, 1938.

[5] S. Hecht, Handbook of General Experimental Psychology, Clark University Press, Worcester, Mass., 1934; Chapter 14 (see especially page 793).

to the temporal muscles. Other muscles of the body were similarly affected. Comparative measurements of individual muscles and of the total amount of muscular tissue indicated that the effect is on the muscular system in general.

The temporal muscles of adult male guinea pigs, castrated before sexual maturity, remain small and flat, as in the adult females. The muscles of such castrated males did not respond to treatment with gonadotropic hormone. This treatment was likewise ineffective in spayed females. These observations indicate that the presence of the gonads is necessary for the production of muscular hypertrophy.

The microscopic examination of the ovaries of treated animals showed, among other changes, considerable hyperplasia and hypertrophy of the interstitial tissue.[1] This suggested that the gonadotropically stimulated interstitial tissue of the ovaries was responsible for the stimulating effect upon the muscles.

Various experiments were then performed in order to determine particularly the effect of the androgenic hormone. Castrated immature males and spayed as well as normal adult females were treated with androgenic hormone (Testosterone Propionate), which represents the testicular interstitial secretion. A definite hypertrophy of the temporal and other muscles of the body resulted.

In another experiment castrated immature males and adult females, both spayed and normal, were treated for a period of 6 to 8 weeks with progesterone (Proluton) and with an estrogen (Amniotin). No definite effect was observed upon the voluntary muscles. On the other hand, when androgenic hormone was combined with either the progesterone or the estrogenic hormone, a general muscular hypertrophy resulted.

In conclusion, it may be stated that the androgenic hormone has a stimulating effect upon the muscles, producing enlargement after prolonged administration. The temporal muscles show a very pronounced response. Because of their superficial position, their enlargement can be readily recognized by palpation. The source of the androgenic hormone in the normal adult male and in the gonadotropically treated female seems to be the interstitial tissue of the testicles and ovaries.

The general muscular enlargement following androgenic treatment offers an explanation for the higher muscular development of the male mammal. It also contributes to a better understanding of the more specific morphological and physiological changes associated with the androgenic action. The importance of obtaining data on the action of the androgenic hormone in conditions associated with muscular deficiencies becomes apparent.

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[1] *Anat. Rec.*, 64; 1936; Suppl. p. 16.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

EXPOSURE METER FOR CINEPHOTOMICROGRAPHY AND STILL PHOTOMICROGRAPHY

EXPOSURE meters for use with cameras and film of various types have been employed for several years. These instruments have generally consisted of some type of "barrier layer" or photronic cell and a suitable galvanometer calibrated in terms of stop opening, etc.

In this laboratory, we have been concerned with the making of still and motion pictures of microscopic subjects in black and white and in color. In the study of the capillary growth about tumor transplants under a window in the rabbit's ear, it was evident that the amount of light transmitted varied tremendously in different microscopic fields. A photoelectric cell and galvanometer system was designed for the purpose of indicating the proper exposure.

One of the first requirements was an inexpensive galvanometer of sufficient sensitivity and ruggedness, with an easily readable scale. The G–M No. 2562–A Pointer-type portable D'Arsonval galvanometer having a resistance of 1,100 ohms with a 60 mm scale and a sensitivity of 0.125 microamperes per mm division fulfils these requirements. This galvanometer is connected with the "G.E. light sensitive cell." This cell, which is small in size and weight, consists of a layer of selenium deposited on a steel plate and has an active area of approximately 1.1 square inches. Although we have not investigated many cells of this type, we find that the above combination is very sensitive and satisfactory.

A four-point switch is mounted on the unit which in one position short-circuits the galvanometer for transportation and protection. The three other points are connected to shunts which provide various sensitivities and make possible the measurement of the light intensities over a wide range. The galvanometer has three scales which are calibrated in "frames per second" for 16 mm Kodachrome film. The three ranges overlap permitting measurements from 0–60 frames per second. A master variable shunt permits the scale ranges to be adjusted for other types of film.

The photoelectric cell is mounted in a fitting which

slides over the barrel of the microscope and holds the cell flat against the ocular lens or the end of the lens barrel if the ocular lens is not used. All the light passing through the optical system of the microscope is intercepted by the cell. The camera speed is adjusted to fit the light intensity, or the light intensity is regulated by rheostat or diaphragm to conform with a desired film velocity. The cell is then removed and the camera lowered into place and the apparatus is ready for use.

The unit is subject to the same limitations as the usual exposure meter. The deflection represents the average of all the light intensities present and is satisfactory when calibrated for the kind of work in question by photographic test.

The use of a photoelectric device for the measurement of light values in photography is well established. The principles have been adapted to cinephotomicrography in the unit above described. The total cost of such a unit is less than $30.00 and soon pays for itself in the saving of film and time.

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LONGEVITY OF PLANT CELLS IN TISSUE CULTURES

THAT certain cells in plants may live for long periods is well known, and Bailey[1] has shown that the cells in a section of cambium mounted in lactose or in liquid petrolatum may continue active cyclosis for weeks. In the course of recent work I have observed numerous examples of a surprising length of survival of plant tissues. Various parts of flowers were detached and placed in sterile culture on nutrient agar. Some of these parts have undergone no regeneration and have shown no significant growth but have lived many times as long as similar structures on normal plants. Examples of this are shown in the following Table 1.

TABLE 1
LENGTH OF LIFE OF PLANT STRUCTURES IN CULTURE

Species	Structure	Time of survival in days
Tulipa Gesneriana	Petal	206
Jasminium fruticosa	"	186
" "	Ovary	236
Erythronium americanum	Ovule	273
Freesia refracta	Sepal	190
Reinwardtia indica	Petal	255
Caltha palustris	"	255
Calendula officinalis	Corolla	277
Scirpus americanus	Section of culm	191
Tradescantia paludosa	Petal	365
" "	Sepal	365
" "	Stamen	365

[1] I. W. Bailey, *Zeitschr. Zellforsch.*, 10: 651–682, 1930.

Most of the structures listed in Table 1 were still vital at the end of the recorded period and might have lived longer.

The cells of *Tradescantia paludosa* were most remarkable. The petals and sepals of this plant are ephemeral and usually live only a day or two after flowering, but in culture they remained alive for an entire year. Cells of these petals and of stamen hairs were plasmolyzed with a sucrose solution. When the sucrose solution was replaced by water many of the cells recovered promptly, although others did not. Active cyclosis was not seen in any of the cells. Pieces of Tradescantia petal 0.5 mm × 1 mm were still alive.

The cultures were made in ½ ounce bottles with bakelite caps which were tightly closed. It is doubtful whether reduced respiration resulted because the amount of inclosed air has been shown to be sufficient for growth and regeneration of masses of tissue much larger than any of these.

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BOOKS RECEIVED

BATESON, R. G. *Timber Drying and the Behaviour of Seasoned Timber in Use.* Pp. xvi + 138. 28 figures. Crosby Lockwood and Son, London. 10/6.

BROUWER, G. A. *The Organization of Nature Protection in the Various Countries.* Special Publication No. 1. Pp. 112. American Committee for Wild Life Protection, Cambridge, Mass.

GRANT, VERNON W. *Psychological Optics.* Pp. 240. 6 figures. The Professional Press, Chicago.

HALDANE, J. B. S. *Heredity and Politics.* Pp. 202. 1 figures. Norton. $2.50.

HOAG, J. BARTON. *Electron and Nuclear Physics.* Second edition. Pp. ix + 502. Illustrated. Van Nostrand. $4.00.

JOHANNSEN, ALBERT. *A Descriptive Petrography of the Igneous Rocks; Volume IV, Part I, The Feldspathic Rocks; Part II, The Peridotites.* Pp. xvii + 523. 1 figures. The University of Chicago Press. $4.50.

KOLLER, GOTTFRIED. *Hormone Bei Wirbellosen Tieren.* Probleme der Biologie, Band 1. Pp. 143. Abb. 2 Akademische Verlagsgesellschaft m.b.H., Leipzig. RM 9,20.

MATTA, DAWOOD. *A Critical Investigation of the Blood Groups and their Medico-Legal Application.* Publication No. 11 of the Faculty of Medicine. Pp. xiv + 2 4 figures. The Egyptian University, Cairo.

MIEHLNICKEL, ERWIN. *Höhenstrahlung (Ultrastrahlung).* Band 44. Pp. xv + 319. 69 Abbildungen. Theodor Steinkopff, Dresden. RM. 25.

Palao Tropical Biological Station Studies, No. 2, 193 Pp. 155–324. 42 figures. Japan Society for the Promotion of Scientific Research, Tokyo. Y2.00 ($1.00)

REICHENBACH, HANS. *Experience and Prediction; An Analysis of the Foundations and the Structure of Knowledge.* Pp. x + 410. The University of Chicago Press. $4.00.

Science Reports of the Tôhoku Imperial University. First Series (Mathematics, Physics, Chemistry.) Vol. XXI No. 3. Pp. 261–413. 10 figures. 1 plate. Maruzen, Tokyo.